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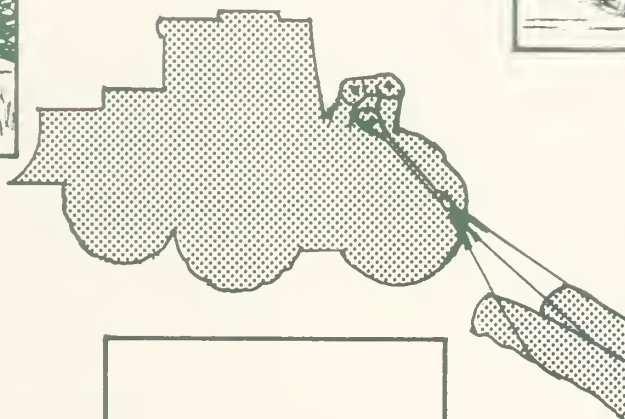
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Influence of Nontimber Resources on Timber Sale Characteristics in the Intermountain West

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RESEARCH SUMMARY

During the early 1980's, financial aspects of timber sales became a focal point of criticism for the Forest Service, U.S. Department of Agriculture. Gone were the days of the timber sale being viewed solely as a timber management tool. In planning a timber sale, land managers are now required to manage for various nontimber outputs that exist in the forest setting. Arguably, provisions for nontimber outputs are costly and result in an unfavorable financial condition for many sales. But actually, little is known about these relationships.

Based on a sample of timber offerings sold from National Forests in the Northern and Intermountain Regions during 1983-85, this research focused on the influence of the nontimber considerations on establishing timber sale characteristics. The nontimber influence was addressed from the standpoint of nontimber resource motivation, managerial purpose, managerial discretion, the interrelationship between timber sale characteristics, and the cost of provisions for nontimber outputs. Analyses used information from the timber sale reports, appraisal summaries, and questionnaire responses provided by land managers with respect to how timber sale characteristics were changed, the nontimber resource that motivated the changes, and so on. A "timber-only" level was estimated for every timber sale characteristic on each timber sale. Nontimber costs were based on the estimated reduction in stumpage value using the actual and timber-only sale characteristic levels. Factor analysis was used to investigate the linkage between the change in timber sale characteristics and the nontimber motivation.

The wildlife resource was found to be the most important nontimber consideration when setting the level of timber sale characteristics for the Northern and Intermountain Regions; soil influences were second. The sale features and requirements most often modified in the Northern Region consisted of acres harvested, number of cutting units, percentage of volume clearcut, slash removal, and cross ditching. In the Intermountain Region, acres harvested, number of cutting units, volume per acre harvested, seeding of temporary developments, and slash removal were modified most often.

Land managers provided information as to the managerial purpose and discretion that influenced the timber sale characteristic levels. Questionnaire results showed that mitigation was the overwhelming managerial purpose in setting timber sale characteristic levels. Land managers indicated that sale features were voluntarily modified, but modifications of sale requirements were mostly policy based.

Analysis of nontimber costs estimated, in terms of 1985 dollars, that the statistical high bid was reduced by \$21.47 and \$12.95 per thousand board feet (M bd ft) in the Northern and Intermountain Regions, respectively. Reductions in statistical high bid reflect only revenues forgone, not Forest Service sale preparation and administration costs nor opportunity costs of alternative management practices on the forest land.

Mitigation and policy-based timber sale modifications accounted for a major portion of the reduction in statistical high bid. The reductions attributed to mitigation efforts were \$16.36/M bd ft in the Northern Region and \$11.55/M bd ft in the Intermountain Region. Policy-based modifications of timber sale characteristics account for \$12.74/M bd ft in the Northern Region and \$10.58/M bd ft in the Intermountain Region.

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INTRODUCTION

Since the early 1980's, timber sale economics on National Forests has become an important public policy issue. Labels such as "below-cost," "deficit," and "unsold" are increasingly used to describe the financial condition of timber sales, a condition determined both by market forces and by timber sale design.

The Forest Service, U.S. Department of Agriculture, mainly influences the financial condition of timber sales through its control over sale design. Forest Service managers vary design characteristics in response to both timber and nontimber objectives. Rasmussen (1985) suggests that a direct link exists between below-cost sales and the management of nontimber resources, that forgone revenues resulting from managing nontimber resources should enter the cash-flow analysis of timber sales. Are these modifications costly? Although the propriety of timber sale modification for nontimber purposes is well established in law and tradition, the extent and cost of these modifications is not well understood.

Schuster and others (1984) showed that management of nontimber resources commonly influences timber sale design. They showed that a high percentage of timber sales incorporates provisions to mitigate harvest impacts on nontimber resources, that location and size of cutting units, along with road density and location, are most commonly modified, and much more. And Benson and Niccolucci (1986), in their study of timber sales in northern Idaho and western Montana, showed that stumpage receipts decreased by about 25 percent for protection of nontimber resources when harvesting timber.

Past research, however, has left many questions unanswered. Specifically, it has failed to deal simultaneously with modification of timber sale characteristics as related to nontimber resource motivation, managerial purpose and discretion available to the manager, and the cost of timber sale modifications. That was the task of this study. Specifically, we first addressed the question of modifying timber sale characteristics in terms of the direction of change (increase, decrease, or no change), the nontimber resource motivating the change (timber, wildlife, and so on), the alternative the manager had selected (mitigation or enhancement), the discretion available (voluntary or policy) in determining the modification, and the interrelationship between timber sale modifications. Second, we addressed the cost of timber sale modifications for nontimber purposes in terms of reduced stumpage value.

METHODS

Data used in this study were obtained from timber sale records and through a questionnaire about timber sale design. The questionnaire was sent to timber sale designers in the Intermountain West. From this information, we learned what was and was not done in timber sales, how often, and why. This information was used to construct a "timber-only" characterization of each sale. Through a system-of-equations approach, the difference in stumpage value between the timber-only and actual sale characteristics estimated the cost of provisions for nontimber purposes. Factor analysis was used to better understand the linkage between sale characteristics.

Sampling and Information Collection

Study data were obtained for a random sample of timber offerings on National Forests in the Intermountain West (consisting of the Forest Service's Intermountain and Northern Regions [fig. 1]) sold between October 1982 and September 1985. Initially all sales were sampled. But after preliminary data analysis, it was determined that only sales consisting of 2 million bd ft or larger would be used. These larger timber sales (larger in volume, acres, and development) provide the land manager with the opportunity to manage for the nontimber influence. Final sample size was 137 timber sales in the Northern Region and 87 in the Intermountain Region.

Data were obtained in two stages. In the first stage, information was collected on 36 timber sale characteristics (sale features and requirements) and 12 appraisal cost items, from the timber sale report and timber sale appraisal summary (Forest Service Form 2400-17). The second stage utilized a questionnaire in which the principal timber sale planner identified the nontimber resource influence and the effect the resource had on the timber sale characteristic level. This information was collected for only a subset of the timber sale characteristics because some characteristics, such as paved-haul miles, were not eligible for modification.

The questionnaire focused on each specific timber sale characteristic, one characteristic at a time. It determined the extent to which nontimber considerations influenced decisions about that characteristic. Seven categories were provided to describe nontimber influence, ranging from "none" to "totally nontimber." Realizing that more than one nontimber resource may be affected by a specific

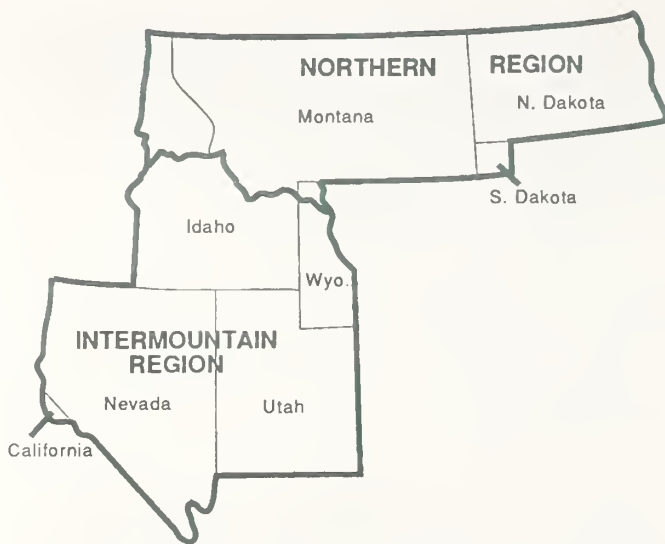


Figure 1—Forest Service's Northern Region and Intermountain Region areas where sale data were analyzed for this study.

modification, we nevertheless asked what was the *primary* (targeted) nontimber resource: visual, recreation, cultural, soil, water, fish, wildlife, or range? We also asked how the sale characteristic was modified: increased, decreased, or not changed? Finally, we assessed the manager's motivation in modifying timber sales.

Motivation was treated in terms of managerial *purpose* and *discretion*. We determined if the purpose of the timber sale modification was to mitigate, enhance, or a combination:

Mitigation: To reduce, moderate, avoid, or rectify adverse on-site effects of the timber sale on nontimber resources or to compensate for adverse offsite effects of management actions elsewhere, as in CEQ (1987).

Enhancement: To improve the status (quantity or quality) of a nontimber resource relative to its presale condition.

The amount of managerial discretion was measured by "voluntary" or "policy" choice. A voluntary choice was a discretionary decision made by the sale's planning team. A policy-based choice was one resulting from a policy directive—a formal, written policy requirement, whether in the form of law or agency regulation.

Measuring Modifications of Timber Sale Characteristics

Information obtained from our questionnaire was used to better understand how and why timber sales were modified for nontimber objectives. We did this by (1) conducting a series of general analyses simply intended to describe broad aspects of modifications, (2) developing a timber-only sale design and comparing it to the actual design, and (3) investigating the linkage between changes.

DESCRIBING TIMBER SALE MODIFICATIONS

Questionnaire results provided an enormous amount of detailed information describing which timber sale characteristics were modified and why. This information readily lent itself to cross tabulations. But because cross-tabulation tables are difficult to comprehend, they were converted to frequency tabulations. Illustrations were developed that portray modification frequency by timber sale characteristic for (1) the primary nontimber resource, (2) managerial motivation, and (3) managerial discretion. The frequency indicates the percentage of the timber sales modified—the ratio of the number of sales that were modified to the total number of timber sales from that Region. Five classes ranging from zero to 100 percent were developed and displayed as shaded boxes. A completely shaded box indicates that the sale characteristic has been modified on at least 31 and at most 100 percent of the timber sales. The percentages between 1 and 30 are depicted by boxes that have increasing degrees of shading. Boxes with no shading indicate no activity (zero percent).

ESTIMATING THE TIMBER-ONLY LEVEL

We developed timber-only sale characteristics to better understand how sale characteristics change on behalf of nontimber objectives and to use later in estimating the cost of nontimber provisions. Our estimates of timber-only sale characteristics were based on the land manager's response to our questionnaire. By timber-only, we meant a situation where, for that sale, each sale characteristic was based on timber considerations only. Under the timber-only—scenario, nontimber considerations were absent or were compatible with an exclusive timber orientation. To do this, we identified a subset of sales (for each sale characteristic) where only timber considerations were used in decisions pertaining to the characteristic.

The process began by arranging the timber-only sales in ascending order with respect to the magnitude of the sale characteristic (fig. 2A). The sale characteristic modified for nontimber purposes is mapped into the timber-only

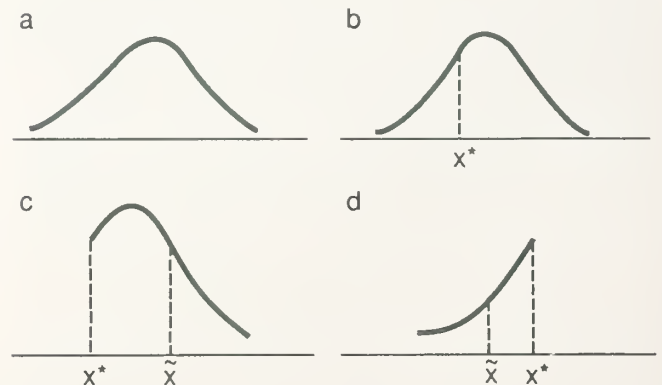


Figure 2—Calculating timber-only sale characteristic level. (a) Timber-only distribution for a specific sale characteristic. (b) The modified sale characteristic (x^*) mapped into the timber-only distribution. (c and d) Calculation of the median (\tilde{x}) based upon the direction of modification provided by the planner.

distribution based on its current sale characteristic level (fig. 2B). Using the information provided by sale planners with regard to the direction of the change and the level of the sale characteristic, the median of the remaining timber-only sales was calculated (figs. 2C, 2D). This median was then used as the estimated timber-only level for that particular timber sale characteristic. The median was selected as the best estimator of central tendency because of the possibility of a skewed distribution (Steele and Torrie 1960).

LINKING SALE CHARACTERISTICS

Do timber sale modifications for nontimber purposes occur individually or in groups or packages of modifications? Presumably, certain timber sale characteristics, such as volume per acre harvested and percentage of the volume clearcut, are related. But simple tabulations can describe only individual occurrences, not combinations; tabulations cannot adequately portray how modifying these timber sale characteristics addresses nontimber purposes. We used the technique of "factor analysis" to better understand the linkage between timber sale modifications.

Factor analysis is a statistical method used to investigate the data covariance structure (see Johnson and Wichern 1982). We used it to explore and detect patterns of association among variables with a view to discovering the link between timber sale modifications. The exploration and detection of the patterns were based on the correlation matrix. The desired result is for a particular group (factor) of variables to be highly correlated among themselves but have relatively small correlations with variables in a different group (factor).

The factor loadings are an important piece of information generated by factor analysis. Factor interpretation is based on the factor loadings and the variables that "load" highly on a particular factor. The factor loadings indicate which variables (timber sale modification) are related to a particular factor. For example, volume per acre harvested and the percentage of the volume clearcut are related. The factor analysis result expected is a factor with large loadings corresponding to volume per acre harvested and percent volume clearcut. Factor interpretation in this study was assisted by using the primary nontimber resource which influenced the modification of the timber sale characteristic.

Estimating Costs of Nontimber Provisions

The cost of the nontimber influence (objective 2) was addressed using a system-of-equations approach. Costs were estimated as the loss in stumpage value resulting from timber sale modifications made for nontimber purposes. This loss was estimated by the difference in stumpage value "with" and "without" nontimber provisions. We used each sale's timber-only characterization as the "without" and the actual characteristics as the "with."

To estimate stumpage value, we created a system of equations that paralleled the residual value (RV) appraisal system used in Forest Service stumpage appraisal.

In RV, the value of stumpage is estimated as final product value less all production and logging costs. We posited that timber sale modifications for nontimber purposes affect logging costs, and changes in logging costs are directly reflected in changes in stumpage value.

We represented the cost portion of the stumpage appraisal system by six regression equations. Five of these equations modeled five general phases or types of logging costs. The sixth equation estimated the amount by which the winning bid on each sale exceeded the sale's advertised rate; this is termed "overbid." Costs for each logging phase and stumpage appraisal overbid were treated as dependent variables; timber sale characteristics were the independent variables. The six models used were:

1. Stump-to-truck costs
2. Transportation costs
3. Slash costs
4. Specified road costs
5. Temporary road costs
6. Stumpage appraisal overbid.

The coefficients of the six-equation system could have been estimated using ordinary least squares (OLS), one equation at a time. But stump-to-truck activities could have an effect on slash and temporary road activities and vice versa. This possible interrelationship between logging phases means that the statistical error terms of these activities (logging phases) might be correlated and the equations might not be independent. Given this possible correlation, OLS should not be used. The technique of Seemingly Unrelated Regression solves the problem of correlated error terms and permits simultaneous estimation of the coefficients. The resulting coefficients are statistically efficient (see Kmenta 1971).

The cost and stumpage overbid equations allowed us to estimate expected stumpage price (high bid). Effective purchaser road credits are subtracted from the estimated high bid. This value, statistical high bid (SHB), was considered a better approximation of the revenues returned to the treasury. If SHB fell below the base rates, the SHB was adjusted for base rates (see USDA FS 1977). All dollars were expressed in 1985 value based on the GNP Implicit Price Deflator (BOC 1987).

RESULTS AND DISCUSSION

Research findings concerning nontimber influences on timber sale characteristics will (1) describe modifications made to timber sales on behalf of nontimber concerns and (2) discuss the cost of these modifications. Modifications will be viewed from the standpoint of managerial purpose, managerial discretion, and nontimber resource influence motivating the timber sale characteristic level. Using the information provided by land managers, we present the timber-only depictions for each timber sale characteristic. These depictions were used to estimate the change in timber sale stumpage value—our measure of costs.

Table 1 is a listing of timber sale characteristics used in this study. Characteristics are grouped into three categories: sale features, sale requirements, and dependent variables and other characteristics. Sale requirements are measured in terms of a 0 or 1. The 0 indicates the

Table 1—Timber sale characteristics

Characteristics	Description	Units
Sale features		
VPA	Volume per acre harvested	M bd ft
ACRES	Acres harvested in sale	Acres
%CC	Percent volume clearcut, seedtree, or right-of-way	Percent
%GSL	Percent volume group selection	Percent
%TRA	Percent volume tractor yarded	Percent
#UNIT	Number of cutting units	Number
RECON	Road reconstruction	Miles
NEW	New road construction	Miles
STEEP	Harvested acres >55% slope	Acres
MID	Harvested acres 35-55% slope	Acres
FLAT	Harvested acres 0-35% slope	Acres
CL	Timber sale contract length	Months
TEMP	Temporary road construction	Miles
YT	Average maximum tractor yarding	Feet
YC	Average maximum cable yarding	Feet
CSP	Corridor spacing	Feet
CWD	Corridor width	Feet
DFEL	Percent volume directional felled	Percent
HP	Percent sale area requiring hand piling of slash	Percent
TOTVOL	Total sale volume harvested	M bd ft
Sale requirements		
GATE	Gates and fences required	1 = Yes; 0 = No
SEED	Seeding of skid trails, temporary roads, and landings	1 = Yes; 0 = No
ACCESS	Road access control	1 = Yes; 0 = No
PLANT	Seed or plant for wildlife cover	1 = Yes; 0 = No
SLASH	Slash removal on trail or streams	1 = Yes; 0 = No
DUSTR	Dust control restrictions	1 = Yes; 0 = No
SNAG	Leave or develop wildlife snags	1 = Yes; 0 = No
HAULRES	Log hauling restrictions	1 = Yes; 0 = No
XDITCH	Cross-ditching or waterbars required	1 = Yes; 0 = No
Dependent variables and other characteristics		
Stump-to-truck	Stump-to-truck costs	Total dollars
Transport	Transportation costs	Total dollars
Slash	Slash costs	Total dollars
Temp Roads	Temporary road costs	Total dollars
Spec Roads	Specified road costs	Total dollars
Bid Premium	High bid-advertised rate	Total dollars
ADBH	Average tree diameter	Inches
UHAUL	Unpaved haul distances	Miles
PHAUL	Paved haul distances	Miles
#BIDS	Number of bidders	Number
SPLS	Selling price, log scale	\$ per M bd ft
SMETH	Timber sale auction type	1 = Sealed; 0 = Oral
PMETH	Pricing method of contract	1 = Escalated; 0 = Flat rate

requirement was absent, and the 1 indicates present. Sale features were measured in continuous units, such as acres, feet, months, and so on. All sale features and all sale requirements were eligible for modification. The total sale volume (TOTVOL) is the product of VPA and acres harvested (ACRES); it is modified through VPA or ACRES. The third category (dependent variables and other characteristics) consists of (1) the dependent variables for the six stumpage appraisal equations and (2) the other sale characteristics used in the stumpage appraisal equations which were not eligible for modification.

Modification of Timber Sale Characteristics

Land managers establish the level of a timber sale characteristic in response to a variety of timber and non-timber resource concerns. Some modifications are made to enhance nontimber resources, others to mitigate against damage. Some are made voluntarily; others result from a policy requirement.

DESCRIPTION OF TIMBER SALE MODIFICATIONS

Table 2 shows the frequency of sale modification, measured by three categories of change: increase, decrease, and no change. By change, we are referring to change from the timber-only level. Land managers indicated whether the actual sale characteristic level had been changed from what would have been done because of the nontimber influence. Hence, table 2 strictly documents the manager's response and does not involve statistical estimation.

Inspection of "no change" columns of table 2 (those under "0") supports two impressions. First, the vast majority of sale characteristics are not changed for nontimber purposes. For example, in better than 96 percent of the sales, decisions concerning corridor width (CWD) were not influenced by nontimber considerations—they were based on timber considerations only. Second, compared to the Northern Region, the Intermountain Region had more sale features and sale requirements not changed for nontimber purposes. In fact, 14 of the 19 sale features and seven of the nine sale requirements had a higher percentage of no modifications for the nontimber purpose.

Table 2 also shows substantial consistency between the Northern and Intermountain Regions regarding frequency of modification for the timber sale characteristics used in this study. For example, modifications made to the number of acres (ACRES), the number of cutting units (#UNIT), and the volume harvested per acre (VPA) were the most commonly modified sale features in both regions. Similarly, seeding skid trails (SEED), planting for wildlife cover (PLANT), and cross-ditching (XDITCH) were the most frequently modified sale requirements.

Although relatively few timber sale features and requirements are modified for nontimber purposes, when modified the magnitude of sale features tends to be lowered and the sale requirements tend to be increased. Table 2 shows that decreases in VPA, ACRES, and #UNIT are quite common, occurring in both the Intermountain

Table 2—Frequency of timber sale modification, by direction of change

Timber sale characteristics	Intermountain Region			Northern Region		
	Percentage of sales + ¹	–	0	Percentage of sales +	–	0
Sale features						
VPA	2.3	39.1	58.6	2.9	36.5	60.6
ACRES	3.4	71.3	25.3	6.6	75.9	17.5
%CC	1.1	27.6	71.3	10.9	31.4	57.7
%GSL	3.4	3.4	93.1	4.4	5.8	89.8
%TRA	2.3	8.0	89.7	4.4	21.9	73.7
#UNIT	20.7	32.2	47.1	24.1	38.7	37.2
RECON	6.9	9.2	83.9	8.0	13.1	78.8
NEW	8.0	18.4	73.6	8.8	29.9	61.3
STEEP	2.3	29.9	67.8	.7	10.9	88.3
MID	4.6	23.0	72.4	2.2	18.2	79.6
FLAT	2.3	11.5	86.2	5.1	13.1	81.8
CL	2.3	12.6	85.1	7.3	21.2	71.5
TEMP	10.3	10.3	79.3	2.9	17.5	86.9
YT	9.2	3.4	87.4	14.6	3.6	81.8
CSP	1.1	1.1	97.7	5.8	0	94.2
YC	0	1.1	98.9	15.3	4.4	80.3
DFEL	16.1	1.1	82.8	24.1	0	75.9
CWD	0	3.4	96.6	0	3.6	96.4
HP	19.5	1.1	79.6	11.7	0	88.3

Sale requirements

GATE	10.3	0	79.3	8.0	0	92.0
ACCESS	58.6	0	41.4	79.6	0	20.4
DUSTR	81.6	0	18.4	78.8	0	21.2
SEED	92.0	0	8.0	87.6	0	12.4
PLANT	16.1	0	83.9	75.9	0	24.1
SLASH	82.8	0	17.2	91.2	0	8.8
XDITCH	58.6	0	41.4	79.6	0	7.3
SNAG	70.1	0	29.9	75.9	0	24.1
HAULRES	28.7	0	71.3	35.8	0	64.2

¹ + = characteristic increased; – = characteristic decreased; 0 = characteristic not changed.

and Northern Regions. The sale characteristics show that under the timber-only scenario the timber sale would have been larger, both in acres and volume harvested. But in certain cases, increasing the level of a sale characteristic can allow for management of the nontimber influence. For example, average yarding distance (YT), directional felling (DFEL), and hand piling slash (HP) are commonly increased to manage for nontimber resources.

The sale requirements (often termed “c-clauses,” referring to clauses in the timber sale contract), such as slash removal (SLASH) and seeding skid trails (SEED), are widely used to manage for the nontimber influence in the Northern and Intermountain Regions. Sale requirements used to manage nontimber resources often restrict logging activities.

TIMBER-ONLY SALE CHARACTERISTICS

Results from our analysis of timber-only sale characteristics provide more definitive estimates of how timber sale characteristics are changed. Note that the timber-only level of a sale characteristic is unaffected by nontimber

influences. The actual level is set by the timber sale planning team, reflecting the influence of the nontimber considerations.

Table 3 presents the average timber-only and actual levels for the timber sale characteristics used in this study. In general, the average timber-only level for sale features is higher than the actual level. The lower actual value indicates that the planner decreases these sale characteristics to manage for the nontimber influence. For example, the average number of acres harvested in a timber sale (ACRES) decreased from about 566 acres to 405 acres in the Northern Region and from about 1,114 acres to 800 acres in the Intermountain Region. But not all sale features were lowered, on average. The percentage of the sale volume with directional felling (DFEL) and the average maximum tractor yarding distance (YT) increased substantially in both Regions. Increasing a timber sale characteristic can be used to protect the nontimber influence, but one must have in mind tradeoffs among timber sale characteristics. For example, an increase in YT allows a decrease in miles of temporary and specified road construction. Avoiding road construction may be viewed as more beneficial in comparison to longer tractor yarding distances.

Table 3—Average magnitude of timber sale characteristics for actual and timber-only sale designs

Timber sale characteristics	Intermountain Region		Northern Region	
	Actual	Timber-only	Actual	Timber-only
Sale features				
VPA	10.28	10.95	20.37	24.49
ACRES	800.03	1,113.70	404.77	565.91
%CC	46.31	55.87	69.70	82.83
%GSL	4.03	3.57	2.80	1.10
%TRA	86.69	87.07	56.93	67.75
#UNIT	21.81	22.66	17.35	15.53
RECON	1.92	1.86	1.87	1.87
NEW	2.56	2.74	3.54	3.76
STEEP	50.40	69.26	47.50	49.08
MID	134.15	182.12	120.04	124.39
FLAT	582.83	656.64	236.33	245.81
CL	48.05	50.11	47.15	49.90
TEMP	1.44	1.40	1.06	1.22
YT	659.29	649.64	672.26	634.08
CSP	56.32	54.02	56.64	50.11
YC	371.64	378.54	678.09	612.42
DFEL	38.45	29.25	32.40	21.29
CWD	6.44	6.61	4.36	6.26
HP	3.16	2.24	.76	.41
Sale requirements				
GATE	.41	.11	.09	.01
ACCESS	.59	0	.80	0
DUSTR	.82	0	.79	0
SEED	.92	0	.88	0
PLANT	.16	0	.24	0
SLASH	.83	0	.91	0
XDITCH	1.00	0	.93	0
SNAG	.70	0	.76	0
HAULRES	.29	0	.36	0

The sale requirements are also used to manage for the nontimber influence. And generally speaking, under the timber-only scenario these requirements would not be implemented. But table 3 also shows, according to timber sale planners, some sale requirements would be required even under a timber-only approach. In our case, the requirement of gates and fences (GATES) occurred in some timber-only sale designs.

NONTIMBER RESOURCES

Figure 3 shows the nontimber resource primarily responsible for motivating changes from timber-only to the actual level of timber sale characteristics, as viewed by the land managers. Three types of information are displayed. First, visual inspection of the overall shading in

figure 3 again indicates (1) that most timber sale characteristics are not altered by nontimber considerations (the large amount of white space in the figure) and (2) that when modifications occur, wildlife is most commonly identified as the primary nontimber resource influencing timber sale characteristic levels (the large amount of dark shading). Similarly, there is almost no shading for the fish resource, the cultural resource, or the range resource. This indicates that these resources rarely influence decisions about levels of timber sale characteristics. There are notable exceptions, such as the range resource being somewhat more influential in the Intermountain Region.

The other two types of information shown in figure 3 involve inspection of the individual columns and rows. By inspecting the *columns*, one can determine what tools are

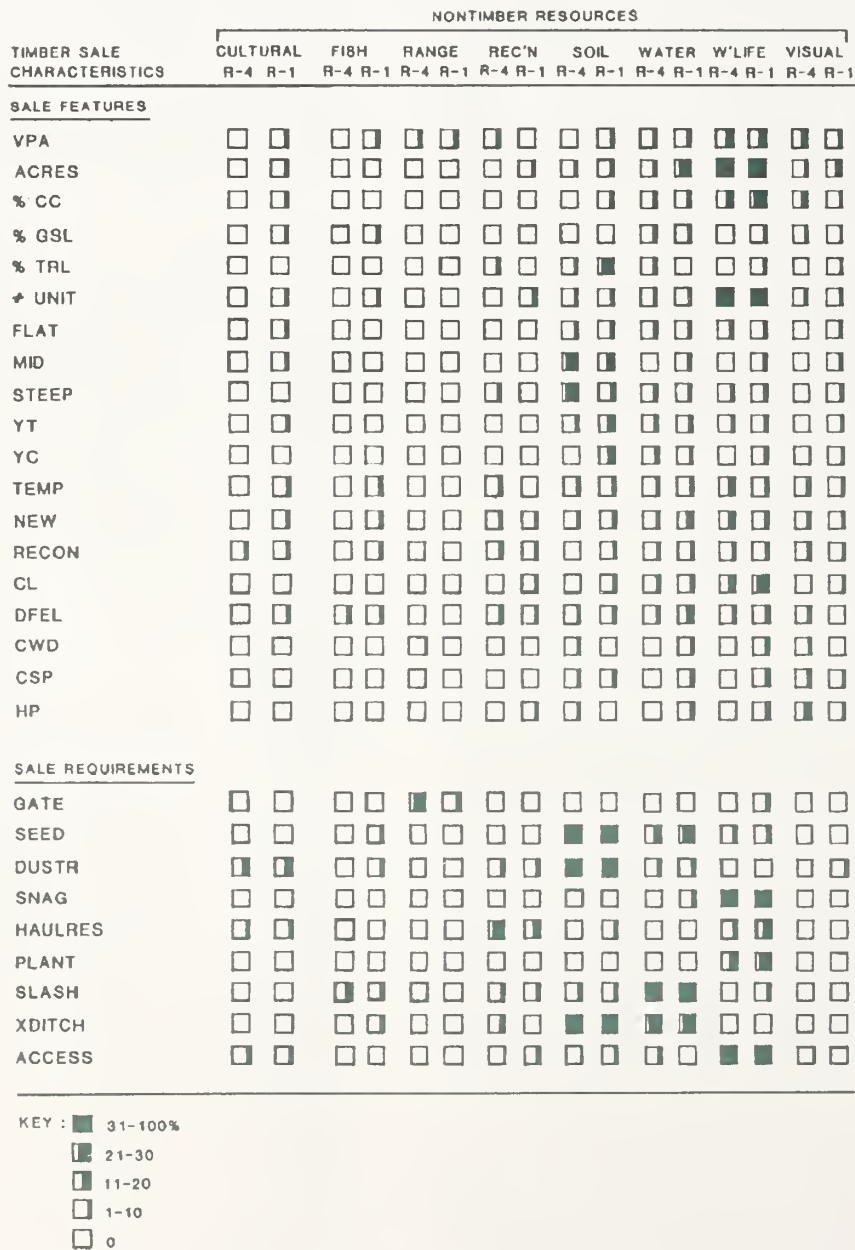


Figure 3—Percent modification for nontimber influences, by nontimber resource (R-4: Intermountain Region, R-1: Northern Region).

used to manage specific nontimber resources. One impression generated is that although many tools are often used to manage a specific nontimber resource, a few tools typically dominate. For example, in the case of wildlife resources, both sale features and sale requirements are used. In the Northern and Intermountain Regions, wildlife considerations are most commonly managed by modifying sale features, such as the amount of acres harvested (ACRES) and the number of cutting units (#UNIT), or sale requirements, such as requiring that snag or wildlife trees (SNAG) be left and restricting access to the sale area (ACCESS). In the case of water resources, management is accomplished almost entirely through sale requirements—restrictions placed on the sale. Cross-ditching roads and trails (XDITCH); seeding roads, trails, and landings (SEED); and removing slash from trails or streams (SLASH) are required on the vast majority of timber sales in the Northern and Intermountain Regions to manage for water resources.

By inspecting the *rows* of figure 3, one can determine what nontimber resource is typically targeted when a specific tool is used. The dominant impression from this analysis is that most tools are used to manage several nontimber resources, not necessarily at the same time, although that is certainly possible. For example, figure 3 indicates that dust control (DUSTR) is modified for the cultural and soil resource. Dust control is usually required adjacent to residential areas or public campgrounds for the purpose of maintaining air quality, and simultaneously accomplishing soil protection by decreasing the erosion potential. Requiring gates and fences (GATES) seems to be an exception of tools being multipurpose; it is used almost exclusively in management of range resources.

LINKAGE BETWEEN SALE CHARACTERISTICS

A timber sale consists of many sale characteristics. In a sense, each characteristic can be viewed as an independent activity. Nevertheless, many characteristics within a timber sale are interrelated. They are used in conjunction, one with another. They are applied as a package. Knowledge of the interdependency leads to a better understanding of how modification of timber sale characteristics is used as a tool to manage nontimber resources. Factor analysis was used to better understand these relationships. This analysis was based on the difference between the actual and timber-only levels for each sale characteristic. Use of the primary nontimber influence, as identified by managers, facilitates understanding and interpretation.

Table 4 shows that nine combinations of sale characteristics were identified for the Northern Region and eight combinations were identified for the Intermountain Region. About half of the packages consist of two-characteristic combinations, the others being either three- or four-characteristic packages. We also show the primary nontimber resource associated with each sale characteristic and the overall direction of change (+, −, or 0) for each characteristic to better understand how these packages of sale characteristics are used in nontimber management. Only about one-fourth of the sale characteristics studied did not belong to a package. Our research suggests that

those characteristics are used individually, with no systematic link to other characteristics.

Table 4 shows that some packages are primarily oriented toward one nontimber resource. For example, decisions in the Northern Region concerning the amount of sale area between 35 and 55 percent slope (MID), the amount of sale area in greater than 55 percent slope (STEEP), and requiring cross-ditching (XDITCH) form a package. That is to say, when one of these characteristics is modified in a sale, the other two are also likely to be modified. In this package, MID and STEEP are decreased and XDITCH is increased, all with the soil resource being the primary target. Harvesting on MID and STEEP ground can increase soil erosion. Decreasing the number of acres on these slopes is a means of accounting for the soil resource influence, as is requiring the use of cross-ditching on steeper slopes. Similarly, in the Intermountain Region the average maximum cable yarding distance (YC), the contract length (CL), and the volume per acre (VPA) are commonly decreased as a package, all with wildlife being the primary nontimber resource target.

But table 4 also shows identical packages of timber sale characteristics aimed at different nontimber resources. In the Northern Region, corridor spacing (CSP) and corridor width (CWD) are often changed together, but they are aimed at different primary targets, the soil and visual resource, respectively. Corridor spacing and width also form a package in the Intermountain Region, but managers indicated they were primarily motivated by visual considerations only. The Intermountain Region also has mixed-target packages.

MANAGERIAL MOTIVATION—PURPOSE AND DISCRETION

Managerial Purpose—Given that sale characteristics are modified to manage for the nontimber considerations, we next describe those considerations in terms of managerial purpose: mitigation and enhancement. Generally speaking, mitigation is preventing or moderating damage to a nontimber resource while enhancement actually improves it.

Figure 4 presents the results pertaining to managerial purpose. By inspection, one can quickly conclude that mitigation of the nontimber influence is the dominant motivating factor when modifying the timber sale characteristic. And of the two types of sale characteristics used in mitigation, sale requirements dominate. SEED, DUSTR, SNAG, SLASH, XDITCH, and ACCESS are used in both Regions on at least 31 percent of the sales. These contract clauses mitigate the damaging effect of skid trails and temporary roads by requiring seeding and cross-ditching, controlling dust on haul roads, assuring that wildlife trees are either developed or left, cleaning of slash in streams and trails, and restricting access to the harvested area. The remaining contract clauses are implemented on less than 31 percent of the timber sales.

Mitigation is also the dominant motivation behind changing timber sale characteristics. In the Intermountain and Northern Regions, volume per acre harvested (VPA), the number of acres harvested (ACRES), percent volume clearcut (%CC), the number of cutting units (#UNIT), and the miles of new road construction (NEW)

Table 4—Timber sale characteristics packages, with direction of change and primary non-timber resource

Intermountain Region			Northern Region		
Timber sale characteristics	Change ¹	Primary nontimber resource	Timber sale characteristics	Change	Primary nontimber resource
YC	—	WILDLIFE	MID	—	SOIL
CL	—	WILDLIFE	STEEP	—	SOIL
VPA	—	WILDLIFE	XDITCH	+	SOIL
CSP	+	VISUAL	CSP	+	SOIL
CWD	—	VISUAL	CWD	—	VISUAL
DUSTR	+	SOIL	%CC	—	WILDLIFE
SLASH	+	WATER	VPA	—	WILDLIFE
SEED	+	SOIL			
TEMP	+	WILDLIFE	SLASH	+	WATER
YT	+	SOIL	DUSTR	+	SOIL
GSL	+	VISUAL	GATE	+	RANGE
ACCESS	—	WILDLIFE	SNAG	+	WILDLIFE
GATES	+	RANGE	ACRES	—	WILDLIFE
RECON	—	WATER	TEMP	+	SOIL
FLAT	—	WILDLIFE	YC	—	SOIL
MID	—	SOIL			
PLANT	+	WILDLIFE			
NEW	—	WILDLIFE	NEW	0	WATER
SNAG	+	WILDLIFE	RECON	—	WATER
HAULRES	+	REC	HAULRES	+	WILDLIFE
TRL	—	SOIL	GSL	+	WILDLIFE
			PLANT	+	WILDLIFE
			#UNITS	+	WILDLIFE
			DFEL	+	WATER
			CL	—	WILDLIFE

¹+ = increase; — = decrease; 0 = no change.

are sale characteristics most often modified to mitigate the harvesting activity. VPA and ACRES can be used separately or in combination to mitigate. For example, harvesting fewer acres and less volume per acre leads to a timber sale having less impact in total volume and number of acres harvested. Modifying the percentage of volume clearcut allows one to mitigate the harvesting activity by decreasing the volume harvested per acre (similar to VPA) and the number of acres that are cleared of standing volume. The number of cutting units (#UNIT) also relates to sale size, and its mitigating effect is similar to VPA and ACRES. Modifying the miles of new road construction (NEW) has the mitigating effect of restricting the nonroaded areas that would be opened to timber and other resource management.

But nontimber enhancement does occur, though less frequently than mitigation. In the Northern and Intermountain Regions, sale features, such as volume per acre harvested (VPA) and acres harvested (ACRES), along with new (NEW) and reconstructed (RECON) road building, are modified to enhance the nontimber resource. Sale requirements, such as wildlife snags (SNAG), planting for wildlife cover (PLANT), and access control (ACCESS), are modified to enhance nontimber resources in both Regions.

In general, figure 4 indicates that timber sale characteristics are only occasionally modified to enhance nontimber resources. At most, only 1 to 10 percent of the timber sales was modified for enhancement purposes. The low percentage of timber sales modified for enhancement may be a conservative estimate, however, because the land manager's response considered only the primary resource. It is possible to enhance the timber resource (the primary resource) and also indirectly enhance a nontimber resource. This occurrence would not appear in the percentages presented in figure 4. The mitigation responses are not similarly affected because mitigation is a direct action taken to protect a specific resource.

Managerial Discretion—Another aspect of the manager's motivation deals with the latitude available in modifying a timber sale characteristic to manage for the nontimber influence. Decision-making discretion was measured only as being voluntary (unconstrained) or as policy-based (a requirement).

Figure 5 presents the results pertaining to managerial discretion. The figure indicates that most modifications are voluntarily made in the Intermountain and Northern Regions (darker shading in the voluntary column). Of the timber sale characteristics voluntarily modified, sale

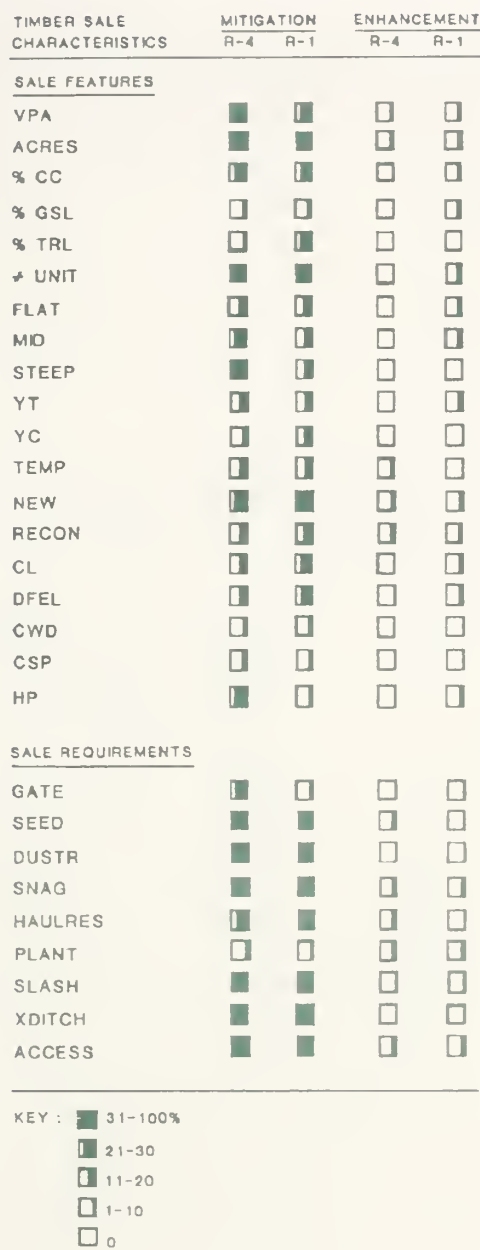


Figure 4—Percent modification for mitigation or enhancement purposes (R-4: Intermountain Region, R-1: Northern Region).

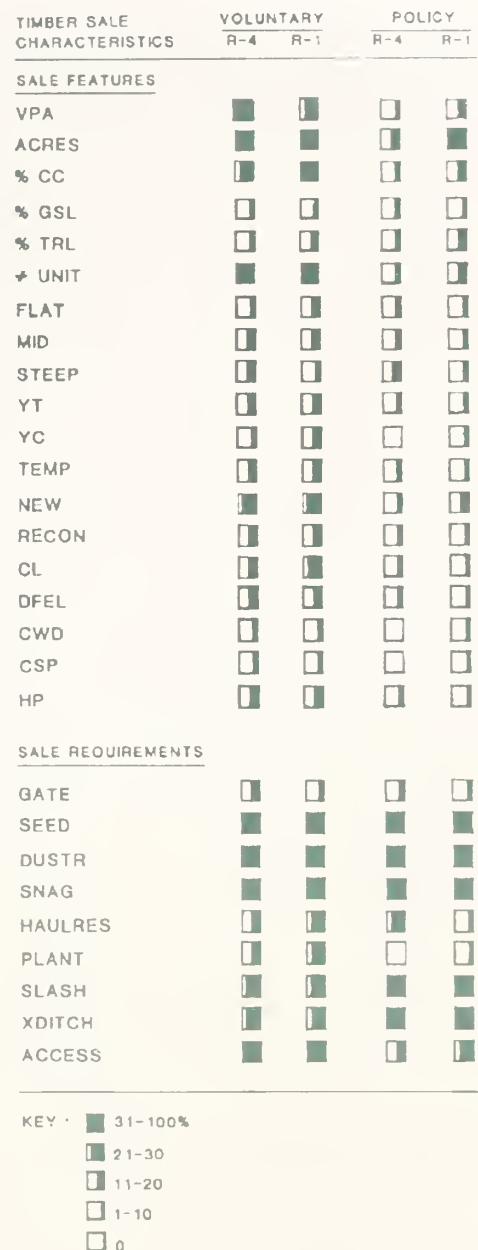


Figure 5—Percent modification for voluntary or policy-driven purposes (R-4: Intermountain Region, R-1: Northern Region).

requirements tend to be modified to a greater extent than are sale features. Sale requirements that are voluntarily modified on at least 31 percent of the timber sales include SEED, DUSTR, SNAG, and ACCESS. Only three of the 19 sale features are voluntarily modified on at least 31 percent of the timber sales in both Regions. These three sale features are VPA, ACRES, and #UNIT in the Intermountain Region, and ACRES, %CC, and #UNIT in the Northern Region.

When decision-making discretion is policy-based, sale requirements is the tool overwhelmingly chosen. SEED, DUSTR, SNAG, SLASH, and XDITCH are modified on at

least 31 percent of the timber sales in the Intermountain and Northern Regions. The most frequent response for the sale features is only in the range of 1 to 10 percent

Cost of Nontimber Provisions

The cost of the nontimber influence was estimated as the difference in stumpage value, expressed as statistical high bid (SHB), from a situation where all sale characteristics were set at their timber-only levels versus where they were set at the actual levels. This was done by modeling the residual value approach to stumpage appraisal using a system of equations.

Statistical Equations—From a statistical standpoint, the seemingly unrelated equations used to estimate the total dollars of SHB (see details in appendix tables 6 and 7) were quite satisfactory. The percentage of the variation explained by the equations (R^2) ranged from 30 (the transport equation) to 68 percent (the stump-to-truck equation) in the Intermountain Region and 13 (transport) to 78 percent (stump-to-truck) in the Northern Region. The equations contained a total of 22 different variables for the Northern Region and 24 for the Intermountain Region. Individual equations contained as few as two independent variables, as in the case of the equations for temporary roads, and as many as nine variables, as in the case of the Northern Region's stump-to-truck equation. (See Schuster and Niccolucci 1989a for presentation and illustration of similar equations.)

The cost equations for each appraisal phase and stumpage appraisal overbid were measured in terms of total dollars, not dollars per thousand board feet. This allowed changes in total dollars of costs and overbid to be viewed without the simultaneous influence of the changes in total volume harvested. For example, modifications, such as volume per acre harvested and acres harvested, change the cost of logging *and* the total volume harvested. Equations measured in total dollars allowed us to monitor changes in appraisal cost and total volume separately. Only at the final step of the analysis were the total dollars and total volume divided to estimate costs in dollars per thousand board feet.

Statistical High Bid—The cost of sale modifications for nontimber purposes used the statistical equations along with the timber-only and actual levels of the sale characteristics. Table 5 presents the estimated statistical high bids (SHB's) for the Intermountain and Northern Regions. The results indicate SHB's for the Intermountain Region would have been about \$37/M bd ft for the timber-only timber sale design and \$24/M bd ft for the actual design, for a difference of about \$13/M bd ft. This difference amounts to approximately 54 percent of the actual SHB. The estimated revenue forgone for the nontimber influence in the Northern Region is more than \$21/M bd ft, again about 54 percent of the actual SHB. In both Regions, stumpage value losses represent a 35 percent decrease from the timber-only SHB. Effects of base rate adjustment on SHB are reported in Schuster and Niccolucci (1989b).

Managerial Purpose—The majority of the costs were intended to mitigate adverse effects of the timber sale in the Intermountain and Northern Regions. The estimated costs of mitigation and enhancement were:

Managerial purpose	Intermountain Region	Northern Region
----- 1985 \$/M bd ft -----		
Mitigation	11.55	16.36
About even	.09	2.98
Enhancement	1.31	2.12
Total	12.95	21.47

Approximately 76 percent of the costs in the Northern Region and 90 percent in the Intermountain Region were

Table 5—Statistical high bid and the cost of the nontimber influence

Sale design	Intermountain Region	Northern Region
----- 1985 \$/M bd ft -----		
Timber-only	37.06	61.40
Actual	24.11	39.93
Difference	12.95	21.47

attributed to modifications intended to mitigate adverse effects of the timber sale. The remaining effect was accounted for by enhancement and the situation where mitigation and enhancement were about equally important.

Managerial Discretion—The cost of managerial discretion was consistent between the Regions, as it was with managerial purpose. The estimated costs of managerial discretion for the Intermountain and Northern Regions were:

Managerial discretion	Intermountain Region	Northern Region
----- 1985 \$/M bd ft -----		
Voluntary	2.37	8.73
Policy	10.58	12.74
Total	12.95	21.47

Policy-driven timber sale modifications accounted for 59 percent of the costs in the Northern Region; this compares to 82 percent of the costs in the Intermountain Region. Recall, figure 5 (presented earlier) showed most modifications were made voluntarily, but the costs portray a very different result. The explanation of this is as follows—timber sale modifications made voluntarily were less expensive than the required modifications.

MANAGEMENT IMPLICATIONS

The previous sections have highlighted the timber sale characteristic and how it was used to manage for the nontimber influence. The modification of the timber sale characteristic and its effect on stumpage price, the nontimber resource being managed, and the managerial motivation were addressed. Several of the findings have interesting management implications.

The land manager indicated that a majority of the timber sale characteristics were not modified for nontimber influences. But the statistical high bid in the Intermountain and Northern Regions was reduced by approximately 55 percent. This indicates that the modifications made, though few, were costly in terms of the reduction in statistical high bid. This may suggest that the manager needs to know not only the magnitude of modification, but also the corresponding effect on stumpage price as well.

A majority of the modifications were voluntarily motivated, according to the land manager. These voluntary changes account for about 18 and 41 percent of the reduction in statistical high bid in the Intermountain and Northern Regions, respectively. The voluntary nature of the modifications simply means the manager was not compelled by some policy requirement to implement

changes. If not required to modify the sale characteristic, did the benefits generated by the voluntarily modified sale characteristic equal or exceed the costs? Knowledge of the costs and benefits derived from voluntary actions will lead to sound economic decisions.

The factor analysis results showed timber sale modifications to be related to, and in certain cases providing for, the same nontimber influence. Understanding the linkages among sale characteristics will allow the land manager to produce more efficiently designed timber sales. Understanding the linkages will allow the land manager to efficiently account for the nontimber influence, and thus have the least impact on revenue returned to the treasury.

We estimated the cost of provisions for nontimber resources to be about \$13 and \$21/M bd ft in the Intermountain and Northern Regions, respectively, based on reduction in SHB. But this measure can be criticized because it was influenced partially by volume reductions. Some could argue that the volume is simply being shifted to the future. This is partially true, and this loss could be viewed as an opportunity cost of consuming in the future rather than the present. But some of the volume not harvested may never be available for harvest; trees left for wildlife escape routes or for streamside protection are examples. Also, the decrease in SHB may be attributed to sale design and layout. The sale design that considers the nontimber influence may not be efficient from a harvesting standpoint (Schuster and others 1984). If the sale design restricts the purchaser from harvesting the stumpage in the most efficient manner, the purchaser will decrease the bid price. This decrease in bid price cannot be captured in the future.

To this point we have considered the cost of the nontimber influence strictly as a percentage reduction in statistical high bid. There are other means of expressing this cost. For instance, nontimber influences represent almost 9 percent of the \$149/M bd ft average logging cost in the Intermountain Region and about 8 percent of the \$156/M bd ft average logging costs in the Northern Region. Similarly, in terms of the average final product value (log scale), the cost of the nontimber influence is approximately 3 percent in the Intermountain Region and 6 percent in the Northern Region.

Finally, throughout this paper the unit of measurement has been thousands of board feet, but acres is the unit of measurement used in land management. The cost of the nontimber influence from the standpoint of acres har-

vested is \$133.13 per acre in the Intermountain Region and \$437.34 per acre in the Northern Region. These represent about 9 percent of the \$1,531 per acre of logging costs in the Intermountain Region and 14 percent of the \$3,178 per acre logging costs in the Northern Region.

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APPENDIX: STUMPAGE VALUATION EQUATIONS

Table 6—Intermountain Region stumpage valuation equations

Equations	Coefficient	Standard error	R ²
Stump-to-truck			0.68
VPA	1,262.65	3,127.52	
ACRES	112.25	34.94	
%TRA	-4,552.40	860.39	
#UNIT	3,842.25	1,102.09	
STEEP	472.24	168.57	
YT	164.10	62.00	
DFEL	-1,023.14	360.59	
Constant	553,315.00	9,494.30	
Transport			.30
UHAUL	3,807.98	535.24	
PHAUL	3,282.25	535.40	
HAULRES	-33,178.30	18,306.50	
ACCESS	13,914.50	17,180.30	
DUSTR	8,670.38	22,207.00	
Constant	105,482.00	31,771.50	
Slash			.56
ADBH	-441.87	1,060.22	
VPA	-1,014.28	684.15	
ACRES	25.36	7.09	
%CC	360.51	102.03	
STEEP	59.25	30.66	
CSP	108.87	39.51	
#UNIT	667.66	215.11	
SNAG	11,578.20	6,907.69	
Constant	16,222.80	18,300.40	
Temp Road			.49
TEMP	3,273.00	333.82	
FLAT	-3.29	1.19	
Constant	3,990.50	934.30	
Spec Roads			.39
NEW	9,571.20	2,400.62	
RECON	7,604.36	2,494.03	
STEEP	268.64	54.50	
Constant	38,228.10	11,474.40	
Bid Premium			.31
SPLS	-.012	.008	
VPA	3,794.98	1,698.58	
YT	182.75	40.66	
CL	968.75	949.32	
PMETH	34,504.00	21,750.60	
SMETH	-20,631.40	29,803.20	
#BIDS	23,213.20	11,961.80	
Constant	-176,161.00	53,247.20	

Table 7—Northern Region stumpage valuation equations

Equations	Coefficient	Standard error	R ²
Stump-to-truck			0.78
VPA	18,266.50	1,650.36	
ACRES	1,211.28	121.71	
ADBH	-29,839.50	4,387.79	
%CC	-1,089.51	409.74	
YT	79.47	46.03	
#UNIT	4,424.47	1,750.45	
%GSL	2,260.60	1,179.02	
STEEP	538.70	188.92	
FLAT	-490.83	130.53	
Constant	111,181.00	75,474.00	
Transport			.13
UHAUL	4,384.44	760.84	
PHAUL	1,982.19	652.74	
ACCESS	9,998.45	22,370.60	
DUSTR	34,064.00	22,895.20	
Constant	101,084.00	35,254.70	
Slash			.48
ADBH	-4,601.96	1,437.35	
VPA	922.65	529.84	
ACRES	139.58	29.02	
%CC	136.07	132.44	
%GSL	-564.46	384.24	
FLAT	-130.39	31.50	
CSP	264.05	63.01	
#UNIT	2,294.25	583.31	
SNAG	-23,857.10	9,434.56	
Constant	68,969.70	25,079.80	
Temp Roads			.31
TEMP	3,684.93	481.98	
FLAT	-14.76	3.49	
Constant	5,164.12	1,239.49	
Spec Roads			.18
NEW	12,204.00	2,659.01	
RECON	5,652.78	3,158.11	
STEEP	23.65	74.22	
Constant	74,393.60	15,276.90	
Bid Premium			.49
SPLS	.07	.01	
ACRES	-213.34	91.73	
CL	2,939.23	1,367.02	
PMETH	-74,367.50	44,280.00	
#BIDS	61,234.20	9,700.30	
Constant	-140,550.00	69,759.50	

Niccolucci, Michael J.; Schuster, Ervin G. 1990. Influence of nontimber resources on timber sale characteristics in the Intermountain West. Res. Pap. INT-422. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 12 p.

Sale requirements were modified to accommodate nontimber concerns in a majority of the timber sales studied. Wildlife resources were the most frequent nontimber concern. The number of cutting units and total acres harvested were the sale features most often modified. Land managers indicated that mitigation was the dominant managerial purpose and that modifications were made voluntarily. Nontimber costs were estimated at \$12.95 per thousand board feet in the Intermountain Region and \$21.47 per thousand board feet in the Northern Region.

KEYWORDS: timber harvest, logging costs, system of equations, stumpage value



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